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Effect of psychological treatment on cognitive bias in motor vehicle accident-related Posttraumatic Stress Disorder

Trishul Devineni[a,*], Edward B. Blanchard[a], Edward J. Hickling[b], Todd C. Buckley[c]

[a]*University at Albany-SUNY, Albany, NY, USA*
[b]*The Sage Colleges and Capital Psychological Associates, Albany, NY, USA*
[c]*National Center for PTSD, Boston VA Medical Center, Boston University School of Medicine, Boston, MA, USA*

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Abstract

The modified or ‘‘emotional’’ Stroop paradigm has been frequently employed in previous evaluations of information processing models of Posttraumatic Stress Disorder (PTSD) and other anxiety disorders. These studies have frequently documented an attentional bias to trauma-specific threatening stimuli in PTSD patients. However, the response of the Stroop color-naming interference effect to psychological treatment has yet to be tested in a trauma population. The present study evaluated the effects of three treatment conditions on the Stroop interference effect in motor vehicle accident (MVA) survivors with PTSD. Following treatment, participants were classified as either treatment responders or nonresponders. Participants named the color of three types of stimuli: MVA trauma-specific words, neutral words, and nonwords. Results showed that change in selective color-naming interference for trauma cues was unrelated to treatment response or modality at either posttreatment or follow-up. Findings cast doubt on the clinical utility of the modified Stroop test as a measure of treatment outcome in this population.

Keywords: PTSD; Stroop; Information processing; Cognitive bias

* Corresponding author. Present address: Department of Psychiatry and Health Behavior, Medical College of Georgia, Augusta, GA 30912-3800, USA. Tel.: +1-706-823-7076.
E-mail address: headache@albany.edu (T. Devineni).

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1. Introduction

According to the Diagnostic and Statistical Manual of Mental Disorders-4th Edition (DSM-IV; American Psychiatric Association, 1994), among the hallmark features of Posttraumatic Stress Disorder (PTSD) are recurrent and intrusive cognitive phenomena (e.g., nightmares, flashbacks, and intrusive recollections of the trauma) that seem to occur without cue. Thus, cognitive processes such as selective attention and memory bias appear to play a central role in the clinical presentation of PTSD. Because of this emphasis on cognitive phenomena in the syndromal diagnosis, information processing models of the etiology and maintenance of PTSD have been developed over the past 20 years and are receiving increased research attention. Among the recent models, Beck and Clark (1997) have proposed a general theoretical account of the anxiety disorders, including PTSD, using an information processing approach.

One of the primary areas of research by experimental psychopathologists working within the information processing framework has been on attentional processes presumably involved in the development and maintenance of PTSD (e.g., Foa, Steketee, & Rothbaum, 1989). The concept of attentional bias (i.e., the selective allocation of attentional resources to threat or danger-related stimuli) plays a central role in most cognitive theories of the anxiety disorders. Many reports have emerged in the last two decades documenting the presence of attentional biases among a number of different anxiety disordered populations (for a recent review of this literature, see Williams, Mathews, & MacLeod, 1996). A reliable result shown across these studies is that anxiety disorder patients exhibit selective attention toward stimuli relevant to their clinical concerns, especially when these disorder-related cues are presented subliminally (i.e., outside conscious awareness).

The modified Stroop paradigm (Foa, Feske, Murdock, Kozak, & McCarthy, 1991; Stroop, 1935), also referred to as the ‘‘emotional’’ Stroop task, has been the primary methodology used to assess attentional biases in studies of PTSD patients. Since attentional biases play a major role in the information processing models of anxiety disorders, it is not surprising that the much of the experimental work in this area has been conducted using the modified Stroop paradigm. The modified Stroop test involves the serial presentation of disorder-relevant (i.e., emotionally salient) words in different colors interspersed randomly with neutral words or nonword letter strings. The subject’s task is to name the color of the stimulus item as quickly and accurately as possible while ignoring all other aspects of the stimulus. The target or ‘‘threat’’ stimulus words are usually selected on the basis of pretesting of potential words that are theoretically linked to the clinical disorder and that elicit significantly longer color-naming delays relative to neutral stimuli and/or compared to the responses of normal control subjects. The original color-naming delay was observed for color words presented in an incongruent physical color resulting in ‘‘interference’’ for the task of naming the physical color of the stimulus word (Stroop, 1935). The so-called Stroop effect is one of the most often replicated findings in experimental psychology (MacLeod, 1991). The primary difference between the original version and the modified Stroop paradigm is the nature of the target stimuli: substitution of emotionally salient stimulus words for neutral color-meaning words. It is argued that the meaning of the stimulus word, whether a color word or disorder-related word, can interfere with or produces a delay in the naming of the word's physical color by drawing away attentional resources at a preconscious or conscious level of information processing. This cognitive bias may be learned from life experience or some individuals may be predisposed through basic temperamental or other biological factors.

Experimental paradigms such as the modified Stroop test may be less susceptible to the demand characteristics of introspective (subjective), self-report measures thereby minimizing the response bias inherent in such measures (Williams et al., 1996). Moreover, some information may simply be inaccessible to conscious introspection if it resides primarily in cognitive structures only responsible for early-stage preconscious mental processes (Beck & Clark, 1997). Thus, nonintrospective measures like the modified Stroop test may be more sensitive and specific to the automatic attentional biases associated with PTSD. Objective assessment of controlled strategic processes is also made possible with the modified Stroop test. In this way, a more accurate and thorough understanding may be acquired of the information processing mechanisms involved in PTSD. Such understanding may lead to more reliable and valid diagnosis thereby informing selection of more appropriate treatments.

A small but growing body of literature indicates that the Stroop interference effect to disorder-related material may be responsive to psychological treatment in various clinical anxiety populations. Response to conventional drug and nondrug treatments for PTSD has been assessed almost exclusively via subjective report, either self- or clinician-administered. Objective measures of treatment response in PTSD are largely unavailable, although there are promising developments in other methodologies such as psychophysiological assessment (e.g., Blanchard et al., 1996). To date, no study has been conducted examining within-subject, pre- to posttreatment effects for the modified Stroop paradigm in MVA-related PTSD. Furthermore, no previous study to the best of our knowledge has evaluated pre-to-post changes on selective Stroop interference to PTSD-related cues in other trauma populations (e.g., rape victims, combat veterans).

2. Treatment studies with the modified Stroop paradigm

The modified Stroop paradigm has been employed in a small number of previous studies to assess treatment effects on attentional biases to threatening information in clinical anxiety groups with diagnoses such as generalized anxiety disorder (GAD), specific phobia, and social phobia.

In a study comparing cognitive-behavioral group therapy, phenelzine, and pill placebo for social phobia, Mattia, Heimberg, and Hope (1993) found social phobics judged to be treatment responders ($n = 17$) evinced significantly decreased color-naming delay for social threat-related words but not for physical threat words or neutral words compared to 12 treatment nonresponders. Thus, this treatment effect for Stroop interference reduction was specific to social threat words. The authors did not report correlations of changes in the clinical measures following treatment with changes in social threat interference effects. They also did not report comparisons of treatment modality on differential changes in social threat interference effects from pre- to posttreatment.

The amelioration of the threat-specific attentional bias with exposure-based treatment has been further demonstrated in two studies of spider phobics. In the earlier study, Watts, McKenna, Sharrock, and Trezise (1986) randomized 28 spider phobics to either a four-session in vivo desensitization treatment or to a no-treatment waiting list condition. Desensitization showed a significant effect on reduction of color-naming delays at posttreatment for spider words only. There were concomitant effects of treatment on Subjective Units of Distress (SUDS) ratings, Behavioral Avoidance Test (BAT) distance scores, and scores on the standardized Spider Phobia Questionnaire. Unfortunately, the authors did not report correlation analyses of changes in spider word interference following treatment with the other phobia measures.

More recently, Lavy, van den Hout, and Arntz (1993) treated 36 spider phobics using an intensive, one session hierarchical exposure treatment. These authors report that response latency to color name spider words was significantly decreased for phobics at posttreatment compared to nonphobic controls and was specific to the threatening stimuli among the spider phobic group. Significant improvements from pre- to posttreatment levels were also observed on the BAT and Spider Phobia Questionnaire.

In a similar investigation using a two-session in vivo exposure treatment, Lavy and van den Hout (1993) report on a sample of 25 spider phobics showing significantly decreased threat interference scores following treatment, an effect again specific for spider-related words. Correlations of BAT scores and self-reported fear with Stroop interference for spider words were not reported.

Effects of cognitive-behavioral treatment on reduction of disorder-relevant Stroop interference has been demonstrated in at least two studies of GAD. Mathews, Mogg, Kentish, and Eysenck (1995) report on a study of 24 GAD patients and 23 nonpsychiatric matched controls assessed with the modified Stroop test at pretreatment, posttreatment, and again at 3-month follow-up (GAD patients only). Following the seven-session anxiety management training, there was a marginally significant decrease in threat (physical and social words) interference scores from pretreatment levels for the GAD group as compared to normal controls who showed no change over the test–retest interval. No significant change in threat interference scores was observed for the GAD group between posttreatment and 3-month follow-up.

In a second study, Mogg, Bradley, Millar, and White (1995) conducted a long-term follow-up of GAD patients who were assessed with the modified Stroop on three occasions: pretreatment, posttreatment, and at 18 months posttreatment. Compared to controls, the GAD group following six sessions of anxiety management training did not show significantly greater interference scores for anxiety-related words relative to depression-related and neutral words irrespective of masking condition, although this difference was present at pretreatment. However, there was no evidence indicating the maintenance of this treatment effect on threat interference scores at 18-month follow-up. With respect to the presentation factor, patients did show greater color-naming delays for anxiety words in the masked than in unmasked condition. For pre- to posttreatment changes, reduction in self-ratings of anxious thoughts was positively correlated with decrements in the interference effect of masked GAD words; the same relation was significant at 18-month follow-up. The authors also found for long-term changes between initial testing and 18-month follow-up, that decreased trait anxiety (STAI) was positively associated with attenuated interference for unmasked GAD words.

Taken together, the results of these studies examining the effects of treatment on cognitive biases in anxiety disordered patients indicate that such threat-specific biases may be attenuated or eliminated as a function of treatment. Moreover, there is some preliminary evidence, albeit inconsistent, that decreases in attentional bias are associated with improvement on behavioral and self-report measures following treatment. Clearly, more studies are needed using the modified Stroop paradigm in different clinical anxiety samples to determine the reliability of this treatment effect within and across the various anxiety disorders. One glaring limitation of this literature is the small sample size available in most of the treatment studies. Coupling these sample sizes with the expectation that Stroop interference effects are generally small to moderate in size (Williams et al., 1996), it is clear that statistical power is compromised and we must be cautious about drawing conclusions of null findings from this data.

Objective measures of treatment response in PTSD are largely unavailable. To date, no study has been conducted examining within-subject, pre- to posttreatment effects for the modified Stroop paradigm in motor vehicle accident (MVA)-related PTSD. Furthermore, no previous study, to the best of our knowledge, has evaluated pre- to-posttreatment changes on selective Stroop interference to PTSD-related cues in any trauma population (e.g., rape victims, combat veterans).

3. Theoretical basis for treatment effects on cognitive bias

Well-developed information processing models of response to cognitive-behavioral treatment for anxiety disorders have been proposed (e.g., Beck & Clark, 1997; Foa & Kozak, 1986). These models implicate the central role of exposure and cognitive restructuring procedures in the mechanisms of therapeutic change on maladaptive cognitive structures underlying pathological fears. Evidence of alterations in attentional biases following treatment of anxiety disorders may be best conceptualized within the framework of an ''emotional processing'' theory proposed by Foa and Kozak (1986). In this model, the extended and repetitive presentation of the feared object or situation is thought to provide corrective or incompatible information leading to a reprocessing of fear memory structures composed of three essential propositions (elements): the stimulus element, the response element, and the meaning element. These authors propose that successful evocation of the fear memory in therapy by exposure to information closely matching the threat representation in the anxiety disordered patient sets in motion several mechanisms leading to potentially therapeutic changes in the fear structure.

3.1. Experimental hypotheses

Foa and Kozak's (1986) emotional-information processing model of the therapeutic efficacy of exposure-based therapies for the anxiety disorders offers a meaningful theoretical framework in which to cast the examination of changes in attentional bias as a result of cognitive-behavioral treatment in MVA survivors with PTSD.

Within this theoretical framework and based on previous research findings (for a thorough review, see Williams et al., 1996), the following two primary hypotheses emerge. First, we expect that PTSD patients responding to treatment will show evidence of emotional reprocessing as indicated by decreases in attentional bias to fear (trauma)-related words from pre- to posttreatment on the modified Stroop test. Second, we predict that PTSD patients in the present study will show a decrement in attentional bias to threatening stimuli presented at levels unavailable to strategic controlled processes (conscious awareness) as a result of treatment.

Also consistent with previous research of individuals with PTSD (for a thorough review of studies documenting subliminal and supraliminal cognitive biases in various PTSD populations including MVA survivors, see Buckley, Blanchard, & Neill, 2000), PTSD patients responding to treatment in the present study are hypothesized to show reduced attentional biases to threat-related stimuli presented at a level of conscious awareness and volitional control (i.e., strategic processing level).

In addition, we will explore the possibility that CBT may be relatively more effective than supportive psychotherapy and a no-treatment wait list control condition in reducing or abolishing attentional bias to disorder-specific threat stimuli in these patients. To the best of our knowledge, no study has yet examined in any PTSD population the relative efficacy of different therapeutic modalities on amelioration of cognitive bias to trauma-specific information.

Finally, to examine the relation between clinical picture and Stroop interference effects, we will analyze whether changes in attentional bias from pre- and posttreatment are associated with changes on clinical measures of PTSD symptomatology and related psychopathology. These analyses will address the issue of the clinical utility of the modified Stroop paradigm as a potential assessment procedure in the evaluation of this patient population. Together, these exploratory analyses will be conducted to investigate the potential diagnostic and prognostic implications of selective trauma word interference effects.

4. Method

4.1. Design and dependent measures

The primary theoretical analyses of the study were conducted using two separate ANOVA models: First, a 2 (MVA diagnostic group: PTSD and non-PTSD) $\times$ 2 (Assessment time point: pre- and posttreatment) mixed factorial design, with repeated measures on the second factor; and second, a 3 (treatment condition: cognitive-behavioral, supportive psychotherapy, and wait list control) $\times$ 2 (pre- and posttreatment) mixed-factorial ANOVA. The primary dependent measure generated from the Stroop task was reaction time for vocal response measured in milliseconds.

To reflect magnitude of differential color-naming delays for PTSD relative to neutral (control) words, an interference score was computed for PTSD words in each presentation condition at both pre- and posttreatment. The interference scores were calculated by subtracting the mean color-naming response latencies for neutral words from the mean reaction times for PTSD words. This method of computing threat interference indices was consistent with the approach taken in previous modified Stroop studies examining treatment effects on cognitive bias in various anxiety disorder groups. These four PTSD interference scores served as the primary dependent measures of attentional bias to trauma cues used throughout all subsequent analyses in this report.

4.2. Participants

Twenty-three community adults (5 males, mean age 34.6 years, S.D. = 9.2; 18 females, mean age 42.7 years, S.D. = 13.5) recruited from advertisements in local media and referred by local healthcare practitioners participated in this experiment. They were recruited as part of a larger treatment study of MVA survivors who were 6 to 24 months postaccident and who at the time of enrollment met DSM-IV diagnostic criteria for PTSD or sub-syndromal PTSD. Only participants who completed the treatment protocol and underwent both pre- and posttreatment Stroop assessments were included in the analyses for this report.

If deemed eligible based on a comprehensive intake assessment, participants were randomized to one of three treatment conditions within the clinical trial:

cognitive-behavioral, supportive psychotherapy, or wait list control (delayed treatment).

4.3. Measures and assessment procedures

Diagnoses of PTSD were established using the Clinician-Administered PTSD Scale (CAPS; Blake et al., 1997), a semi-structured interview based on DSM-IV (American Psychiatric Association, 1994). The CAPS has demonstrated adequate reliability and validity for use as a diagnostic instrument of PTSD (Weathers & Keane, 1999). The Motor Vehicle Accident Interview, a locally constructed semi-structured interview was used to elicit detailed information about the participant's accident, physical injury status, subjective reactions, and other significant MVA-related sequelae (Blanchard & Hickling, 1997). The Structured Clinical Interview for DSM-IV (SCID; First, Spitzer, Gibbon, & Williams, 1996) was used to evaluate lifetime and current status for all Axis I disorders.

Participants completed a number of self-report measures at each assessment time point. All self-report inventories used have demonstrated adequate reliability and validity. The PTSD Checklist (PCL; Weathers et al., 1993) and Impact of Event Scale (IES; Horowitz, Wilmer, & Alvarez, 1979) were administered to evaluate the presence and overall severity of PTSD symptoms. The IES also yields subscale scores for intrusion and avoidance symptoms. Patients completed the Beck Depression Inventory (BDI; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961) to assess the degree of depressive symptoms. The Brief Symptom Inventory (BSI; Derogatis & Melisaratos, 1983) was administered as a measure of the overall level of psychological distress. The State-Trait Anxiety Inventory (STAI; Speilberger, Gorsuch, & Lushene, 1970) was given to assess both current and persisting levels of anxiety. The National Adult Reading Test-Revised (NART-R; Blair & Spreen, 1989) was administered to all participants as an estimate of verbal aptitude emphasizing extent of general vocabulary and familiarity with words. This measure served as a control variable to evaluate potential moderating effects of verbal intelligence on color naming of words on the modified Stroop task. The NART-R is a brief experimenter-administered measure that correlates reasonably well with the WAIS-R verbal intelligence scales (Blair & Spreen, 1989).

4.3.1. Assessment procedures

Stroop assessments were conducted at pre- and posttreatment. Clinical assessments were conducted at pre-, posttreatment, and follow-up. Detailed information about assessment procedures can be found in Blanchard and Hickling (1997).

4.4. Treatment

Treatment ranged in length from 8 to 12 weekly sessions ($M = 9.8$, S.D. $= 1.2$ for cognitive-behavioral therapy (CBT) group; $M = 9.7$, S.D. $= 1.4$ for supportive psychotherapy condition). Eligible participants were matched on essential PTSD-related variables and randomized to one of the two treatment conditions or to a wait list control condition. The wait list condition was 10 weeks in duration, at the completion of which, subjects were reassessed and those still symptomatic for PTSD were crossed-over to the CBT condition.

4.4.1. Treatment conditions

The first treatment condition, CBT, was composed of the following elements: intensive psychoeducation about PTSD and normalization of trauma experience; written trauma confession/narrative exposure therapy; progressive muscle relaxation training; systematic desensitization with imaginal and in vivo exposure to avoidance hierarchy; cognitive restructuring of negative self-talk; enlisting spouse, partner, or significant other as co-therapist; behavioral activation and pleasurable events scheduling; exploration of depressive schema, faulty logic, and correction of maladaptive cognitions and erroneous interpretations. The second treatment condition, supportive psychotherapy, encompasses attention placebo and nonspecific or common factors of a helping relationship including the following components: a supportive therapeutic alliance with a warm, caring, and experienced professional; a detailed description of the PTSD syndrome and normalization of the symptomatic response to traumatic events; elicitation of a psychosocial history, developmentally, and exploration of previous losses and traumas with emphasis on how they were handled or coped with; subsequent focus on current life problems, feelings associated with the problems, and possibility of underlying meaning, themes, or issues all done in a supportive context.

4.5. Treatment responder status

For the purpose of comparison on the Stroop task, participants were classified as either treatment responders or nonresponders based on change in categorical diagnostic status. *Treatment success* was defined as a recovery from PTSD indicated by a change in diagnostic status from pre- to posttreatment of full to non-PTSD.

4.6. Stimulus materials and apparatus

The modified Stroop task was comprised of three categories of words or nonword letter strings presented to the participant on a computer screen. Each stimulus set consisted of eight items. One set of PTSD-related words was used. Two groups of categorized neutral words were used. A single composite score was derived by averaging the mean vocal response latencies for each word type. This neutral word composite score was used in all analyses for this study and in computation of the interference scores for PTSD words. See Buckley, Blanchard, and Hickling (2002) for details about the stimulus materials used in this modified Stroop procedure.

Emotional valence of the stimulus words was assessed using self-ratings made along a visual analogue scale for each word in the Stroop task. A valence score was computed for each word category using the mean valence ratings for the eight words in each of the three word groups.

4.6.1. Apparatus

The modified Stroop task was administered in a computerized format. The Micro Experimental Laboratory (MEL; Schneider, 1988) software package was used to develop and implement the experiment. Vocal response emission was recorded by means of a voice-activated relay housed in a serial response hardware unit (model number 200A-Psychology Software Tools, Inc.). The voice-activated relay, which determined the time elapsed for emission of a vocal response, was connected to a headset with microphone worn by the participant.

Stimulus words were presented on the computer screen in either masked or unmasked conditions. Words in the unmasked condition remained on screen until a vocal response was recorded. Target words in the masked condition appeared on screen for 16 ms and were immediately followed by a backward mask of nonword letter strings matched for character length and color. Each mask remained on screen until a vocal response was collected. Identical Stroop tasks were administered at both pre- and posttreatment.

At the start of the testing session, the experimenter gave all participants standard verbal instructions explaining the Stroop test. The session consisted of 256 stimulus trials with a 2–3 min break provided midway to minimize fatigue effects.

Color-naming errors were defined as the participant saying either the word displayed rather than the presentation color or saying the wrong color. These were recorded for later analysis. False or invalid responses (e.g., participant coughing, irrelevant utterance, other extraneous sound) loud enough to activate the voice relay were coded as such during the experiment and were excluded from the data set for all subsequent analyses. A full debriefing was offered at the completion of the posttreatment session.

5. Results

All analyses reported below were performed using an alpha level of .05, unless noted otherwise. Analyses directly testing our experimental hypotheses were conducted using one-tailed statistical tests. Exploratory analyses indirectly related to our predictions were performed using two-tailed tests. Familywise error rates for analyses involving multiple pairwise comparisons (e.g., post hoc tests) were controlled using standard procedures such as Tukey's HSD. The only exception to this analytic approach was the use of planned contrasts of theoretical interest or a priori analyses directly evaluating the experimental hypotheses.

Table 1
Demographic characteristics of PTSD subsamples

Variable	Treatment responder group ($n = 23$)	
	Responder ($n = 11$)	Nonresponder ($n = 12$)
Age	35.9 (11.2)	45.5 (13.8)
Gender (% M/F)	18/82	25/75
Years of education	12.6 (2.7)	14.3 (1.8)
NART-R	35.8 (15.6)	39.0 (5.6)
Ethnicity (% Caucasian/minority)	82/18	92/8

No between-group values significantly different at $P < .05$. NART-R: National Adult Reading Test-Revised.

5.1. Preliminary analyses

Chi-square analyses revealed that the treatment condition groups and treatment responder groups were both similar with respect to gender distribution and ethnicity. The ethnic composition of the sample was largely Caucasian (87%). One-way ANOVAs indicated that the groups were also comparable on age and educational level; they also did not differ significantly on NART-R scores suggesting that verbal ability was comparable between the groups. Thus, the primary comparison groups did not differ appreciably on major demographic variables. Demographic characteristics for treatment responders and nonresponders are presented in Table 1.

The treatment responders and nonresponders were also compared on the primary measures of PTSD, anxiety, depression, and related distress and impairment (“caseness”) at initial assessment. The groups were not significantly different on any of the major psychopathology measures (i.e., CAPS, BDI, STAI, BSI global severity index, IES, PCL, or GAF).

5.2. Stroop responding at initial assessment

As a preliminary check of initial cognitive bias across this sample, mean vocal response latencies for PTSD and neutral words were compared via dependent sample *t*-tests separately for each presentation condition. Paired differences were nonsignificant for both masked (trauma: $M = 663.3$, S.D. = 162.9; neutral: $M = 649.2$, S.D. = 153.2) and unmasked words (trauma: $M = 695.7$, S.D. = 220.8; neutral: $M = 694.3$, S.D. = 196.0) at pretreatment assessment indicating that the sample did not show the expected larger color-naming delays for trauma words relative to neutral words regardless of presentation level. However, visual inspection of the mean difference for masked PTSD and neutral words revealed increased color-naming latencies for trauma words in the expected direction. This null finding was probably *not* due to inadequate sample size given that reanalysis with the larger sample of PTSD-positive patients who received the Stroop test at initial assessment but not necessarily at posttreatment

($n = 58$) revealed a nonsignificant difference between the vocal response latencies for trauma and neutral words in both the masked and unmasked conditions. Restriction of range would probably *not* alone explain this lack of relationship between word type and pretest color-naming latencies as previous studies using comparable assessment protocols among similar populations of PTSD and other anxiety disorders have consistently revealed significant differences for disorder-relevant words versus neutral words (Bryant & Harvey, 1997; Buckley et al., 2000).

To investigate pretreatment differences on Stroop interference for masked and unmasked PTSD words, independent sample *t*-tests were conducted comparing treatment responders and nonresponders. The groups did not differ significantly for either presentation condition. Since matching on initial Stroop interference scores was not performed for assignment of participants to treatment condition, further *t*-tests (corrected for multiple comparisons by Tukey's HSD procedure) were conducted comparing participants on each level of treatment. No significant differences were found between any of the conditions.

5.3. Valence ratings of modified Stroop stimuli

As valence of disorder-relevant stimulus elements has been proposed as an important aspect of the meaning propositional component of fear structures (i.e., interpretation of threat or danger; Foa & Kozak, 1986), valence ratings of Stroop word stimuli were examined as a function of both primary independent variables in this study: treatment response status and treatment condition. First, a treatment response group (2) by word type (2; valence: PTSD words, neutral words) mixed ANOVA with word type as the repeated measure was performed. The main effect of word type was highly significant [$F(1, 21) = 281.2$, $P < .001$]. The main effect of treatment response group and the interaction of response group by word type were not statistically significant. Examination of the group marginal means revealed that all subjects tended to rate PTSD words ($M = 18.2$, $\text{S.D.} = 9.7$) as more negative than neutral words ($M = 55.1$, $\text{S.D.} = 6.3$). Second, a treatment condition (three levels) by word type (two levels) mixed ANOVA revealed only a significant main effect of word type [$F(1, 20) = 230.9$, $P < .001$]. As before, the nature of the main effect was such that subjects across all three treatment conditions tended to rate PTSD words more negatively than neutral words.

5.4. Treatment effects on PTSD interference scores

As a preliminary check of treatment effects, pre- and posttreatment Stroop interference scores for masked and unmasked PTSD words were separately compared by dependent sample *t*-tests. Paired differences were nonsignificant indicating that selective interference for trauma cues did not change appreciably over the treatment interval.

The analyses addressing our main hypotheses consisted of a 2 (treatment response group: responder and nonresponder) $\times$ 2 (time of assessment: pre- and posttreatment) mixed ANOVA with repeated measures on the second variable. The primary dependent variable in these analyses was a PTSD interference score computed at each assessment point by subtracting the mean color-naming delay for neutral words from the mean color-naming delay for PTSD words separately for masked and unmasked presentation conditions. Results showed that the main effects of both variables were nonsignificant for PTSD interference in both the masked and unmasked conditions. Moreover, the interaction of treatment response group with pre- to posttreatment change in PTSD interference was nonsignificant for both stimulus presentation conditions. To further investigate the effects of treatment within each level of treatment response group, dependent sample *t*-tests were performed on posttreatment masked and unmasked PTSD interference scores. Findings verify that no significant change in threat interference scores occurred over the course of treatment for either responders or nonresponders. The means and standard deviations for masked and unmasked threat interference at each assessment point are presented as a function of responder status in Table 2.

To compare the effects of each treatment condition on PTSD interference scores, 3 (treatment condition: CBT, supportive therapy, and wait list) $\times$ 2 (time: pre- and posttreatment) mixed factorial ANOVAs were performed separately for each masking condition. The main effects and interactions of both variables on changes in interference scores were nonsignificant for both the masked and unmasked presentation conditions (see Table 2). As above, the ANOVAs were followed up by dependent samples *t*-tests to further examine the effects of each treatment condition on pre-post changes PTSD interference scores. These tests failed to reveal any significant pre-to-post reductions in interference scores for any of the treatment conditions.

5.5. Treatment effects on PTSD and related psychopathology measures

As a further manipulation check, a series of 2 (pre- and posttreatment) $\times$ 3 (treatment condition) mixed ANOVAs examining the effects of treatment condition on psychopathology measures were conducted. For the primary clinical measures (CAPS, BSI, BDI, STAI, IES, PCL, GAF) significant main effects were observed for time (pre- to posttreatment) on CAPS total score [$F(1, 20) = 17.9$, $P < .001$]; IES total score [$F(1, 20) = 9.2$, $P < .01$]; and GAF [$F(1, 20) = 8.5$, $P < .01$]. A significant main effect trend for time was obtained for PCL total score [$F(1, 20) = 3.8$, $P = .07$]. A marginally significant time by treatment interaction was observed for IES only [$F(2, 20) = 3.4$, $P = .05$]. Examining the marginal means for IES revealed that both CBT and Supportive groups improved considerably more than wait list from pre- to posttreatment. No significant main effects of treatment condition or time by treatment condition interactions were obtained for any of the other outcome measures.

These nonsignificant results must be qualified by the limited statistical power to detect potentially significant effects with small cell sizes. This limitation was

Table 2
Trauma word interference scores by responder status and treatment condition

Presentation condition	Pretreatment		Posttreatment	
	M	S.D.	*M*	S.D.
Treatment responder status				
Masked				
Responder[a]	6.0	39.4	0.9	294.3
Nonresponder[b]	21.6	47.6	−8.4	53.7
Unmasked				
Responder	15.0	70.5	−16.9	88.2
Nonresponder	−11.2	31.5	7.9	66.8
Treatment condition				
Masked				
CBT[c]	13.6	32.4	−111.4	220.4
Supportive[d]	12.9	51.6	−11.8	49.8
Wait list[e]	16.9	44.6	118.0	307.1
Unmasked				
CBT	−11.8	24.6	−0.07	37.7
Supportive	−3.7	30.3	−7.2	55.7
Wait list	23.7	98.0	−2.1	135.7

PTSD threat interference index: mean color-naming latency for PTSD words minus mean color-naming latency for neutral (control) words in milliseconds; positive interference values represent greater color-naming latencies for PTSD words relative to neutral words; negative values denote relatively greater latencies for neutral words compared to PTSD words. A pre-to-post change in sign from positive to negative of the interference score reflects a relative decrease in color-naming latencies for PTSD words; the absolute value of the difference represents magnitude of change. Similarly, a change in sign of negative to positive reflects an increase in mean interference for PTSD words. CBT: cognitive-behavioral therapy.

[a] $n = 11$.
[b] $n = 12$.
[c] $n = 6$.
[d] $n = 11$.
[e] $n = 6$.

unavoidable due to the small sub-sample of treatment-completing patients ($n = 23$) undergoing a Stroop assessment at both pre- and posttreatment.

5.6. Prediction of clinical status with PTSD interference scores

Pearson correlations were run to explore the possibility that interference effects for masked and unmasked PTSD words (at pre-, posttreatment, and/or pre-post change score) might predict clinical status on categorical diagnoses and continuous measures of psychopathology at posttreatment and 3-month follow-up. For initial PTSD interference scores, there were no significant correlations in either masked or unmasked presentation conditions with any of continuous measures at posttreatment or follow-up. In addition, by logistic regression, pretreatment threat interference was not associated with posttreatment or 3-month PTSD, co-morbid

Major Depression, or GAD categorical status (present, absent) for either stimulus presentation condition.

To examine whether reduction of Stroop interference for PTSD words over the treatment interval was associated with improvement in clinical status over the follow-up interval, pre-post changes scores for PTSD interference were correlated with change scores for clinical status from posttreatment to 3-month follow-up. Pre-post changes in interference scores were not associated with changes in PTSD-related symptomatology, distress, or impairment over the 3-month interval following treatment.

Partial correlations (controlling for the effects of pretreatment differences in threat interference scores) of posttreatment PTSD interference with 3-month clinical measures duplicated these null findings. With respect to diagnostic status at follow-up, logistic regression analyses showed that change in pre-post PTSD interference was not significantly related to changes in PTSD, Major Depression, or GAD at 3 months. Thus, we could find no compelling evidence that changes in color-naming delay for trauma words following treatment predicts maintenance, relapse, or remission of psychopathology at short-term follow-up.

5.7. Correlations of PTSD interference scores with psychopathology measures

Pearson correlations were run to examine the relation between self-report and clinician-administered measures of anxiety and depression and the PTSD Stroop interference indices for masked and unmasked words. For the overall sample at pretreatment, none of the correlations were significant.

Correlations of treatment response sub-samples (i.e., responders and nonresponders) did not yield any significant association between pretreatment trauma interference scores and any quantitative measures of psychopathology.

For the overall sample at posttreatment, there were no significant correlations among trauma interference scores and measures of posttreatment clinical status. Similar null findings were obtained when posttreatment measures were examined within treatment responder and nonresponder subgroups.

To more directly address the issue of whether improvement on psychopathology measures from pre- to posttreatment was associated with reductions in color-naming interference of masked and unmasked PTSD words, change (difference) scores were calculated for each clinical measure. Similarly, pre-to-post change scores were calculated for PTSD interference effects in each presentation condition. No correlations among pre-post PTSD interference change scores and psychopathology measures were significant.

To examine differences between treatment modalities, these same change score correlations were tested as a function of treatment condition. Contrary to expectations, no significant correlations were observed between PTSD interference change scores and psychopathology measures within any of the treatment groups. That is, we failed to observe the predicted association between reductions in trauma word interference effects and reductions in clinical measures within the CBT group as compared to the other treatment conditions.

6. Discussion

The present study evaluated theoretical hypotheses speaking to an explanatory model of anxiety treatment based on information processing theory (Foa & Kozak, 1986). These authors' model attempts to account for how exposure-based therapies (e.g., cognitive-behavioral treatment) produce reductions in pathological fear among anxiety-disordered individuals. Given that individuals suffering from PTSD following serious MVAs exhibit characteristic symptoms of intrusive cognitions, hyperarousal, and hypervigilance toward trauma-related cues, such a theoretical account of cognitive change reflected in attentional bias reductions as a function of successful exposure therapy was seen as promising. However, the results of this investigation lend little support to predictions that emanate from this theory for cognitive change resulting from otherwise successful psychological treatment of PTSD.

6.1. Primary research hypotheses

Contrary to our main hypothesis, the results of this study suggest that response to treatment defined by change in CAPS score using DSM-IV criteria is not associated with concomitant reductions in the interference effect of PTSD words in either masked or unmasked presentation conditions. That is, successful treatment had no appreciable effect on amelioration of attentional bias to trauma stimuli over the course of the test–retest interval. This null finding implies that despite positive treatment outcome, detectable reductions in attentional bias or other cognitive changes as tapped by the modified Stroop task failed to occur at either automatic preconscious or strategic controlled levels of information processing (Beck & Clark, 1997). In fact, to our surprise, the mean color-naming latencies for PTSD and neutral words were comparable at pretreatment suggesting that this patient sample evinced no baseline differences in attentional bias for PTSD words relative to control words.

In terms of our secondary hypothesis, the results provide no support that treatment modality (CBT, supportive psychotherapy, wait list) affects change in color-naming delays for PTSD relative to neutral words from pre- to posttreatment in either presentation condition.

6.2. Other findings related to research hypotheses

Exploratory correlation analyses run between interference effects for PTSD words and standardized measures of psychopathology turn up the same pattern of negative results suggesting no association between trauma content-specific cognitive bias and conventional clinical measures (questionnaire and interview) of PTSD and related psychological problems.

6.3. Limitations

An immediately apparent shortcoming of the present study is the small sample size. The degree to which this factor contributed to the largely null, unexpected, or contradictory findings of this study is unclear. Unfortunately, the sample size cannot be increased because the larger treatment study on which this study was drawing from as a source of subjects has been completed. Clearly, future attempts at replication of this study with larger samples are required in similar trauma populations to establish the reliability of these results.

One might argue that the modified Stroop paradigm is an insensitive measure of the cognitive processes involved in the accessing, activation, and eventual disintegration of a fear network following otherwise successful exposure treatment as described by Foa and Kozak (1986). As alluded to earlier, even if the modified Stroop test is a sensitive measure of attentional bias, the cognitive phenomena assessed by it may have little relation to clinical picture and thus lack clear practical implications. Conversely, one might claim that the exposure procedures utilized in the experimental treatment of this study were insufficiently evocative of the fear memory to produce the kind of emotional processing changes tapped by the modified Stroop task in this trauma population.

Furthermore, even if the exposure procedures were adequately evocative, the complex regimen applied in this study trained individuals in cognitive stress coping techniques that probably operate at the level of strategic controlled processing. The successful application of such techniques during the Stroop testing session may have suppressed the threat interference effect (at least in the supraliminal presentation condition) leading one to incorrectly conclude that apparently successful exposure treatment had no effect on attentional bias. However, this account would not explain why disorder content-specific color-naming delays were absent at pretreatment in this sample. Because the components of CBT, which may have importantly separate effects on attentional bias changes, are largely confounded with each other in this integrated treatment protocol, it is difficult or impossible to confidently ascertain what if any cognitive change is attributable to one or the other component. Thus, a more rigorous test of changes in attentional bias as a function of treatment in this population would require dismantling the CBT condition into its behavioral and cognitive components and evaluating the effects of each on subliminal and supraliminal PTSD threat interference.

6.3.1. Post hoc power analysis

As no-treatment studies employing the modified Stroop paradigm in a PTSD population (irrespective of trauma type or research design) have been conducted thus far, estimating effect size from previously reported findings was not possible. It is likely that the population effect sizes we are dealing with are rather small (estimated eta-squared = .05–.10). This eta-squared value would correspond to a Cohen's *d* effect size of no more than .20 (Cohen, 1988). The main effect of theoretical interest in this study is that of time (pre- to posttreatment assessment) and its 2×2 interaction with treatment responder status (primary hypothesis) and the 2×3 interaction with treatment modality (secondary hypothesis) on change in threat interference scores for PTSD words in masked and unmasked presentation conditions (primary dependent variable). Based on our results, the obtained eta-squared values for the hypothesized 2×2 and 2×3 interaction effects of pre-post change in PTSD interference scores (masked and unmasked conditions analyzed separately) with responder status and treatment condition, respectively, were trivially small (.001–.10).

Another potentially important limitation of this study is the high rates of psychiatric co-morbidity with PTSD, in particular GAD (35%) and Major Depression (44%), present in this sample. It is unclear to what degree concurrent depression and generalized anxiety contaminated the color-naming latencies of the negatively valenced PTSD threat words in either the supraliminal or subliminal presentation conditions. Bradley, Mogg, Millar, and White (1995) and Mogg et al. (1995) have shown that GAD patients who are concurrently depressed do not exhibit interference effects to general threat words in the masked presentation condition. Thus, it appears that automatic processing biases to anxious stimuli are blocked or inhibited in co-morbidly depressed generalized anxiety patients. Moreover, there is considerable evidence from modified Stroop studies of clinically depressed patients indicating that they show a generalized attentional bias to negatively valenced information relative to positive and neutral stimuli at strategic controlled stages of mental processing (Williams et al., 1996).

To what extent this "depressive" pattern of processing bias accounted for the selective interference to trauma words (which were rated as highly negative) among our concurrently depressed PTSD patients is unclear as our sample size was too small to compare the subgroups of depressed and nondepressed subjects on trauma word interference at initial and postassessment.

Finally, while a strength of this study was that it employed a follow-up rather than cross-sectional sample of treated patients for comparison on the Stroop test, we do not have a nonanxiety control group or a non-PTSD clinically anxious group with which to compare the test–retest effects on attentional bias changes separately from those directly attributable to treatment. Such a design would more convincingly isolate the unique treatment effect on PTSD-specific threat interference of primary interest in this study.

It should be noted that many of the findings reported in this study are admittedly the product of post hoc exploration of the data, as our primary a priori analyses did not yield the expected results. These post hoc analyses are reported and discussed in some detail here to offer a better understanding of the nature of these null findings. Our hope is that future studies will surmount these methodological weaknesses to offer clarification of the questions raised by this research.

7. Conclusion

Taken together, these results are largely inconsistent with our primary research hypotheses. Speaking to our first hypothesis, we found no compelling evidence for a reduction in threat interference scores of PTSD words as a function of positive treatment outcome. Although this negative result conflicts with a few isolated reports, the question remains to be systematically examined. Regarding our second prediction, there was no indication of a treatment modality-specific effect on pre-post change in attentional bias to trauma cues.

Moreover, there was no consistent association between standard clinical measures of PTSD and related psychopathology and threat interference scores at any assessment point. Finally, we did not find Stroop interference scores for trauma words in either the subliminal or supraliminal conditions to be useful predictors of clinical status at either posttreatment or follow-up.

To the extent that the emotional Stroop task is a valid measure of selective information processing biases, the results of this study do not lend support to the notion that psychological treatment reliably attenuates or abolishes selective processing of trauma-relevant cues among MVA survivors with PTSD. We were not able to find any evidence for the utility of the modified Stroop paradigm in the evaluation of intrusive cognitions or hypervigilance to disorder-related stimuli in this clinical population.

Further research is needed with a treated MVA–PTSD population using the modified Stroop paradigm and other measures of cognitive bias to clarify the role of information processing variables in the etiology and/or maintenance of psychopathology.

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